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Male scent-producing structures in two moth species: "*Amsacta*" *emittens* (Arctiidae) and *Eutelia blandiatrix* (Noctuidae)

(Insecta, Lepidoptera)

By **Dietrich Schneider**

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The androconial (male scent-producing) organs of the noctuid *Eutelia blandiatrix* and the arctiid "*Amsacta*" *emittens* distribute an odor reminiscent of alpha-keto-butyric acid, similar to that of the male of the European noctuid *Bena prasina*. The morphology of the *Eutelia* and "*Amsacta*" organs is described: they are, respectively, two abdominal hairbrushes and a corema. The chemistry and behavioral meaning of these scents (which are probably pheromones) remains unknown. Electrophysiological tests show that "*Amsacta*" senses, and possibly even produces, pheromones which are known of both sexes of the related genus *Creatonotos*.

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Introduction

In a preceding paper (Schneider et al., 1992) we described the chemistry, morphology and superficial structures of a complex abdominal hairbrush system in the male of the European noctuid moth *Bena prasinana*. The striking and strong odor of these male scent-emitting (androconial) organs was found to come from alpha-keto-butyric acid which has a smell similar to that of several commercial soup spices, typically MAGGI ®. Probably, this odor plays a role in the sexual behavior of *Bena* and would thus be a pheromone. This assumption is in accordance with the fact that the antennae of both sexes of this species possess olfactory receptors for this fatty acid. So far, no behavioral observations could be made to verify this assumption.

The detection of the "Maggi" odor in *Bena* was preceded by observing a similar odor in the male abdominal hairbrush of another noctuid moth, *Eutelia blandiatrix*, in Nairobi/Kenya and later from the male sleeve-organ (corema) of the arctiid moth "*Amsacta*" *emittens* from Kandy/Sri Lanka and Madurai/India.

Material and Methods

"*Amsacta*" *emittens* Walker.

Both sexes of this species (Arctiidae, wingspan 36-40 mm, Figure 1) were light-trapped in the Kandy area. The taxonomic status of this (and also that of the related species "*A.*" *lineola* Fabricius) is uncertain, neither of them is correctly placed in the genus *Amsacta* according to A. Watson (British Museum Natural History, London, pers. comm.). The sexes look very similar, cream-white wings with variable

Fig. 1. "*Amsacta*" *emittens*, female; wingspan 38 mm.

dark longitudinal stripes. The abdomina are yellow on the upper side with black spots, typical of many arctiids. This (probably aposematic) pattern is displayed by the moths when they are disturbed. They lift the wings, show the abdomen and feign death for some minutes. Females have filiform, males bipectinate antennae. We raised a small number of moths from eggs which hatched at room temperature after 6-7 days and the larvae pupated after 3-4 weeks. Pupal time varied considerably between 10 days and several weeks. The larvae fed in captivity on wheat and several broadleaf herbaceous plants, some of which are known to contain pyrrolizidine alkaloids (e.g. *Heliotropium* ssp.). These bitter plant metabolites serve in other arctiids of the genera *Utetheisa* and *Creatonotos* after uptake and storage as protective chemicals and in the males as precursors of the pheromone hydroxydanaidal (Conner et al. 1960, Schneider et al. 1982, Wunderer et al. 1986, Boppré & Schneider 1989, Boppré 1990).

Eutelia blandiatrix Guénée (syn. *E. discistriga* Hampson).

A single specimen of this moth (Noctuidae, Euteliinae, a so called "turntail moth") was caught at a light-trap in Nairobi/Kenya, photographed, its brush organ extended, its Maggi smell noted, but the specimen was lost after its identification (Figure 2). The species is of widespread occurrence in East-Africa; its wingspan is 28-30 mm. We here describe its androconial structures from museum specimens (origin: Nairobi and N-E Tanzania) from the Zoologische Staatssammlung, Munich. Interestingly, West-African moth specimens kept under the same name in this collection are obviously a different species as judged from their male genital armatures and their much smaller androconial organs. The taxonomic status of these species needs to be clarified.

Morphology

Androconial structures of *Amsacta* have been displayed by inflating the male abdomen with air or water and have in both species been studied after KOH-maceration.

Chemistry

Because the odor of the *Amsacta* corema was similar to that of *Bena*, we performed the specific chemical tests for the alpha-keto-butyric acid (which is typical of the Maggi smell) but found no traces of it (Schneider et al. 1992). *Eutelia* has not been available for any laboratory studies.

Electrophysiology

Amsacta was studied with the routine electroantennogram (EAG) technique (Schneider et al. 1992).

Results

Amsacta

Morphology

The corema is everted like the tip of an indented glove finger which is being turned inside out. We have never observed a living male displaying this organ in its behavior, but were able to simulate the eversion in freshly dead males by applying pressure to the abdomen. The corema expands out of an aperture in the ventral intersegmental fold between the sternites 7/8. Figures 3 and 4c show the organ, composed of two lateral, hair-covered rounded sacs combined in the middle by a less prominent part. In the course of artificial eversion the system was found to be "hydraulic", i.e. it expanded by hemolymph

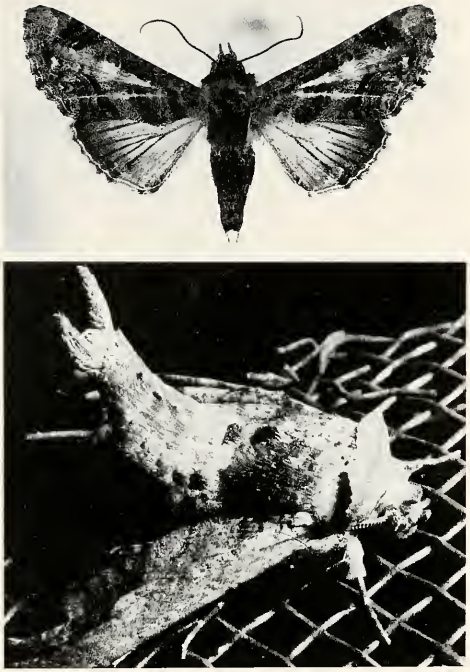

Fig. 2. *Eutelia blandiatrix*. **a**. mounted male from Kenya; **b**. male at light trap (Nairobi). The two "pencil-like" structures at the abdominal tip are not androconial organs. Wingspan 30 mm.

Fig. 3. "*Amsacta*" *emittens*, male. Macrophoto of an artificially everted corema (sleeve organ). Scale 1 mm.

pressure. Under the light microscope the hairs were found to be flat (band like), but may have collapsed into this state during the preparation. The corema bears ca. 350 hairs, maximally 1.9 mm long and 4-5 µm wide.

Dissection of the KOH-macerated abdomen clarified the morphological picture (Figure 4b). in the resting state (when the caudal abdominal segments telescopically overlap one another) the partly sclerotized, complex sternite of segment 8 reaches with an expanded part over sternite 7. This part

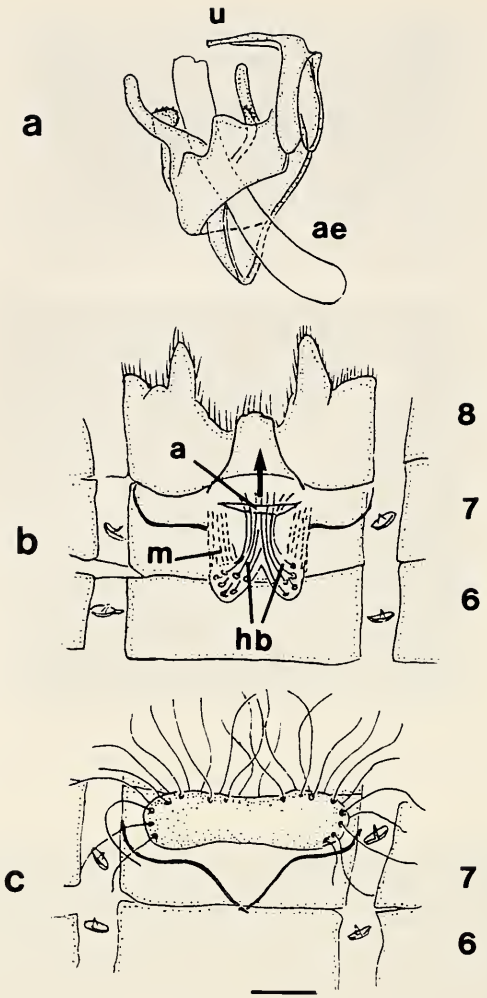

Fig. 4. "*Amsacta*" *emittens* male. Semi-schematic view of: **a**. genital structures (uncus on top); **b**. internal surface view of abdominal segments 6, 7 and 8 cut along the mid dorsal line. Androconial (coremal structures in resting position with opening slit in the 7/8 intersegmental membrane. c. external view of segments 7/8 with everted corema (cf. fig. 3). Scale 1 mm. a: aperture for corema; hb: hairbases; m: empty case of presumed retractor muscle. Arrow: direction of corema eversion.

bears the two lateral halves of the corema which are packed side by side in the unexpanded state but are united as a broad bag when everted. The two symmetrically positioned lateral tubular structures (which appear to be empty after maceration) supposedly contained the retractor muscles of the organ. The tubes which now contain hairs turn (nearly 180 degrees) toward the midline, and the long androconial hairs can be seen to originate from the bend in the tube-wall, their sockets clearly visible; tubes then run in parallel (and unite?) until they end at an aperture through which the abdominal pressure forces the corema out and expands the organ with its semi-spherical fans of hairs (Figures 3 and 4c).

Electrophysiology

EAG recordings were obtained from 5 pectinate, male antennae with long trichoid olfactory sensilla (known from other moths to be sensitive to the respective female attractant-pheromone, Schneider, 1992).

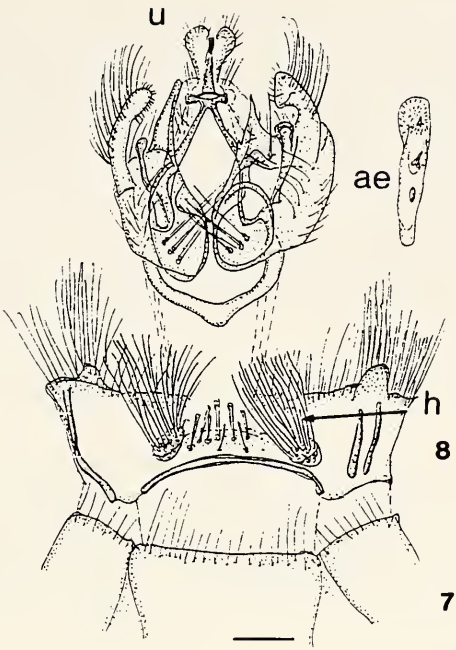

Fig. 5. *Eutelia blandiatrix*, male. Semi-schematic picture of genital structures (ae, aedeagus; u: uncus) and abdominal segments 7/8. Internal view. Abdomen cut ventrally at mid line. Two not everted hair-brushes (h) under Segment 8. Scale 1 mm.

Stimulation with the "*Amsacta*" corema odor had no effect. But the odor of the giant coremata of the related arctiid moth *Creatonotos transiens* elicited EAGs of several times the control amplitude.

Significant EAGs (several times control) were also recorded in response to the odor of the everted female lure-glands of *Creatonotos transiens* and also to its three major long-chain pheromone-components (a triene and two epoxides: Wunderer et al. 1986, Bell & Meinwald 1966). In Amsacta we could not find a female lure gland as in *Creatonotos* but instead tried to stimulate the male *Amsacta* antennae with air blown over the abdominal tip of his female (the location of a tentative gland of a female attractant-pheromone). Here we saw only weak, barely significant EAG-responses.

Eutelia

The eversible structures are two lateral brushes on the 8th abdominal segment which are surrounded by other long hairs which seem not to be of androconial nature (Fig. 5). The two brushes together contain ca. 300 hairs, maximally 2 mm long and 12 µm wide.

Discussion

A corema of the specific shape as in "*Amsacta*" has not been described before. It appears as a miniature edition when compared to the larger coremata of other arctiids (Birch 1979, Wunderer et al. 1987, Boppré & Schneider 1989).

Although the "*Amsacta*" corema has a distinct (albeit weak) Maggi-odor, we have neither the respective chemical evidence that it contains alpha-keto-butyric acid (Schneider et al. 1992) nor any electrophysiological indication that the organ contains this or other volatiles which are perceived by the antenna. The reason for this could be an insufficient sensitivity of the recording procedure, either

in absolute terms or because of a lack of specifically tuned receptor cells. However, the clear responses of the "*Amsacta*" antenna to the corema-odor of the related arctiid *Creatonotos* are puzzling. The giant corema of this species contains up to 0.5 mg of the heterocyclic pheromone hydroxydanaidal (with no Maggi smell that we could perceive) which is an attractant for both sexes. But what might it mean when "*Amsacta*" obviously possesses odor receptors for this compound? Could hydroxydanaidal and not the fatty acid, in principle, also be the major corema-odorant of "*Amsacta*"? Interestingly, hydroxydanaidal can (as far as we know) only be produced by an insect if it feeds on an alkaloidal (pyrrolizidine) precursor (Conner et al. 1980, Schneider et al. 1992, Boppré, 1990). The absence of at least larger amounts of hydroxydanaidal (no antennogram response !) in the "*Amsacta*" corema might then be the result of insufficient alkaloid supply in the larval diet. After all, while the "*Amsacta*" larvae are rather omnivorous, they accept (like the *Creatonotos* larvae) plants which contain the alkaloidal precursor of hydroxydaidal.

Equally interesting are the EAG-responses of the male *Amsacta* antennae to the female pheromone components of *Creatonotos* because they strongly suggest that the composition of a (yet unidentified) female attractant pheromone of *Amsacta* might be chemically similar or identical to these compounds (Bell & Meinwald 1986).

Speculations on the *Eutelia* scent-brush chemistry are not possible. Its odor was rather strong when we detected it by sniffing at the artificially everted brush. We suspect that the striking "turntail" position of the resting moth (only of the males?) might be related to a pheromone emittance but this is not yet supported by any evidence. - Several different groups of moths show such a "resting" position, for instance at light traps. Males of tropical pyralid moths are examples for this. They evert fine fans of hairs near their abdominal tips which are actively moved in a wavy fashion, possibly to aid evaporation of a scent.

The reported androconial organs, their odor and some receptorial responses invite parallel chemical and behavioral studies. Such research on chemical communication requires the maintenance of continuing insect cultures, a condition which we could not fulfil in this case.

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W. Dierl (München) informed me on male-moth genital structures and supplied *Eutelia* specimens. M. Eckrich (U. Freiburg) supplied us with the South-Indian (Madurai) relative of the Sri Lanka "*Amsacta*". Both are, according to the highly appreciated study of A. Watson (Brit. Mus. Natl. History, London), identical. W. Schäfer (Martiensried) attempted to identify the corema odor of *Amsacta*. H. Söchting-Mayr and E. Roth assisted in laboratory work.

Zusammenfassung

Die männlichen Duftorgane der Noctuide *Eutelia blandiatrix* und die der Arctiide "*Amsacta*" *emittens* haben für die menschliche Nase einen typischen "Maggi" Duft. Bei den Männchen der europäischen Noctuide *Bena* wurde ein solcher Duft bereits als alpha-keto-Buttersäure identifiziert (Schneider et al. 1992). Bei den beiden hier beschriebenen Arten konnte bisher weder die Chemie des Duftes, noch dessen Bedeutung für das Verhalten geklärt werden. Das Haarbüschel-Duftorgan von *Eutelia* kommt in ähnlicher Ausführung bei einer Reihe von Nachtfaltern vor. Das schlauchförmige Duftorgan von "*Amsacta*" (Corema) ist in der hier beschriebenen, besonderen Form neu. Es erinnert an eine Miniaturausgabe der bei Arctiiden oft sehr großen Coremata. Deutliche elektrophysiologische Antworten der männlichen "*Amsacta*"-Antenne auf den weiblichen Lockduft des verwandten Arctiiden *Creatonotos transiens* legen nahe, daß auch "*Amsacta*" ein ähnliches oder gleiches weibliches Lockpheromon besitzt. Die antennale Sensitivität von "*Amsacta*" für den männlichen *Creatonotus* Duft (das ist Hydroxydanaidal) suggeriert hingegen, daß auch "*Amsacta*" diesen Stoff produzieren kann, in unserem Experiment aber mangels des Vorstufen-Alkaloids in der Raupennahrung daran gehindert war.

Nomenclatorial note

The name of the noctuid species earlier known as *Bena prasinana* L. (the "green silver lines" of the British authors, the "Jägerhütchen" or "Maggi moth" of Schneider et al. 1992, see also the present paper) has now been changed to *Pseudoips fagana* Fabricius (see I. W. B. Nye: The generic names of moths of the world. Vol. 1, cf. pg. 78 with 414, Noctuidae, part 1, Brit. Mus. Nat. Hist. 1975).

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